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THE BOTANICAL GAZETTE

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CONTENTS:

Contribution to the biology of the organism causing leguminous tubercles. (With plates XII—XV.)—*Geo. F. Atkinson*. 157
The genus Corallorhiza. (With plates XVI and XVII.)—*M. B. Thomas*. 166
George Vasey: a biographical sketch. (With portrait—Plate XVIII.) *Wm. N. Canby and J. N. Rose*. 170
Frost freaks of the dittany. (With plate XIX.)—*Lester F. Ward*. . . 183
Briefer Articles 186
On two new or imperfectly known Myxomycetes. (With plate XX.)—*W. C. Sturgis*.
On the vegetation of hot springs.—*J. Christian Bay*.
Habenaria fimbriata, var. (With illustration.)—*Henry G. Jesup*.
Editorial 190
Current Literature 191
Notes and News 193

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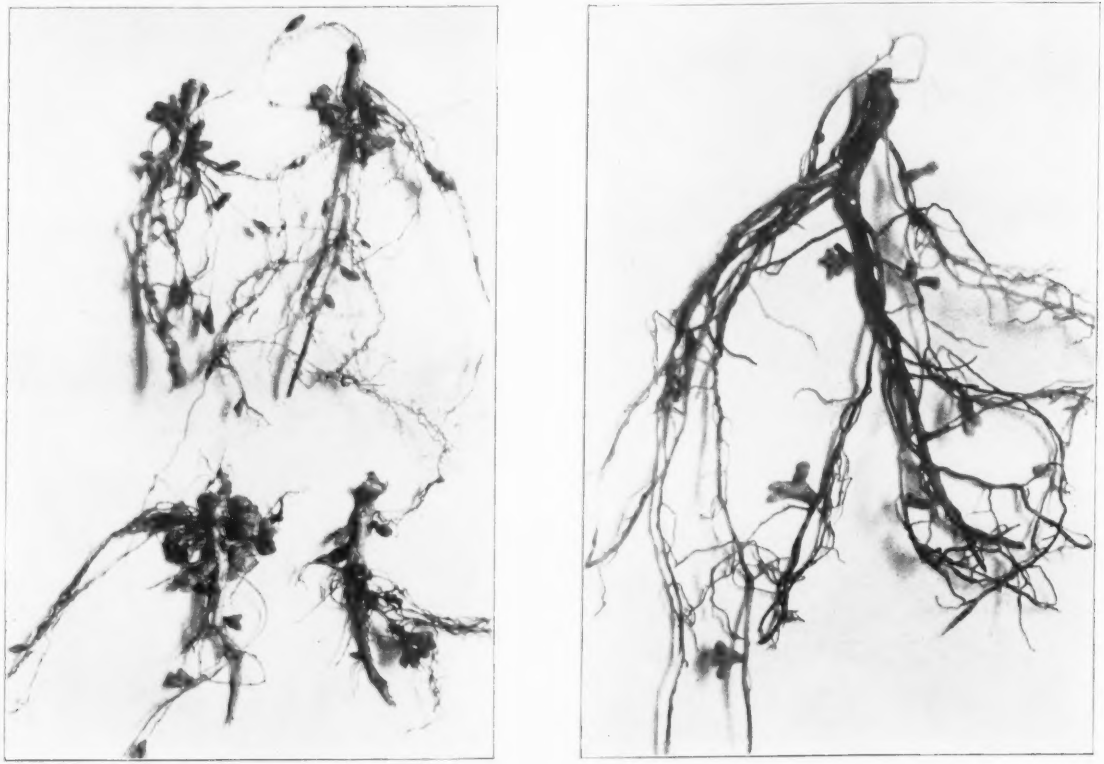
Undescribed plants from Guatemala. XI, by JOHN DONNELL SMITH, *Baltimore, Md.*

On the embryo-sac and embryo of Senecio aureus, by DAVID M. MOTTIER, *University of Indiana, Bloomington.*

On the development of the caryopsis, by RODNEY H. TRUE, *Madison, Wisconsin.*

Contribution to the biology of the organism causing leguminous tubercles. *Secoud Part: historical résumé.*



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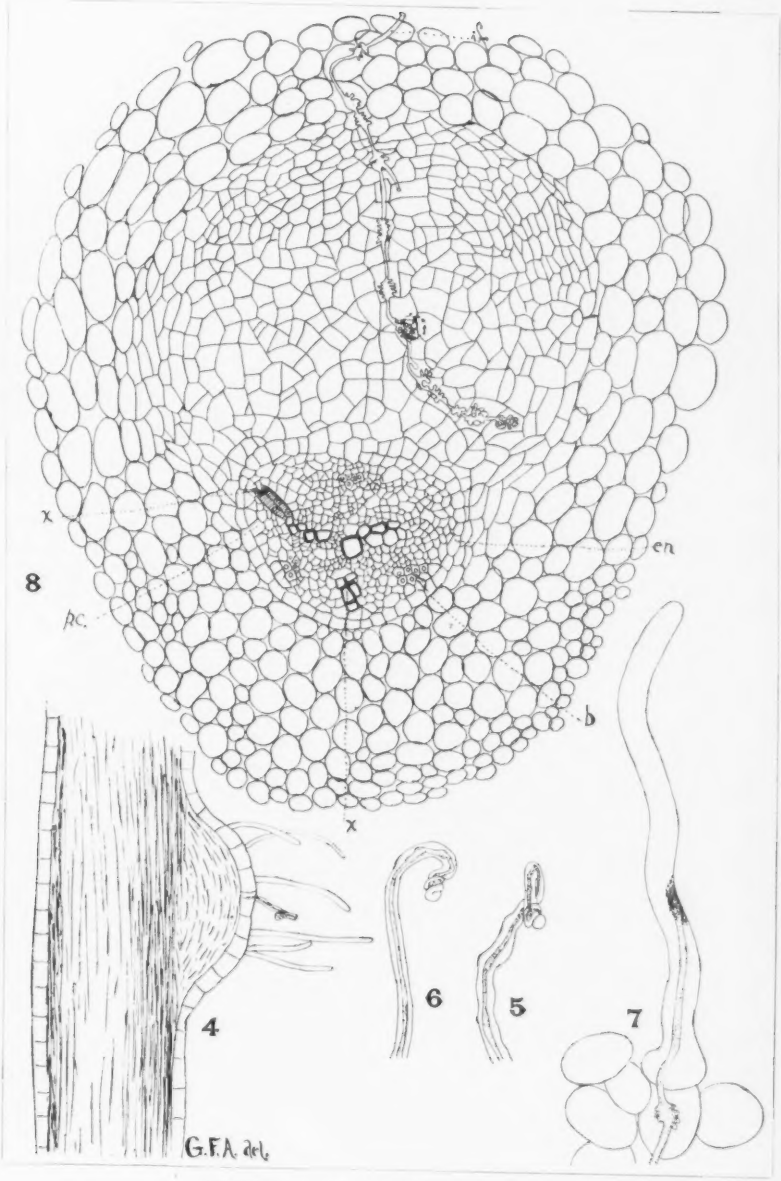

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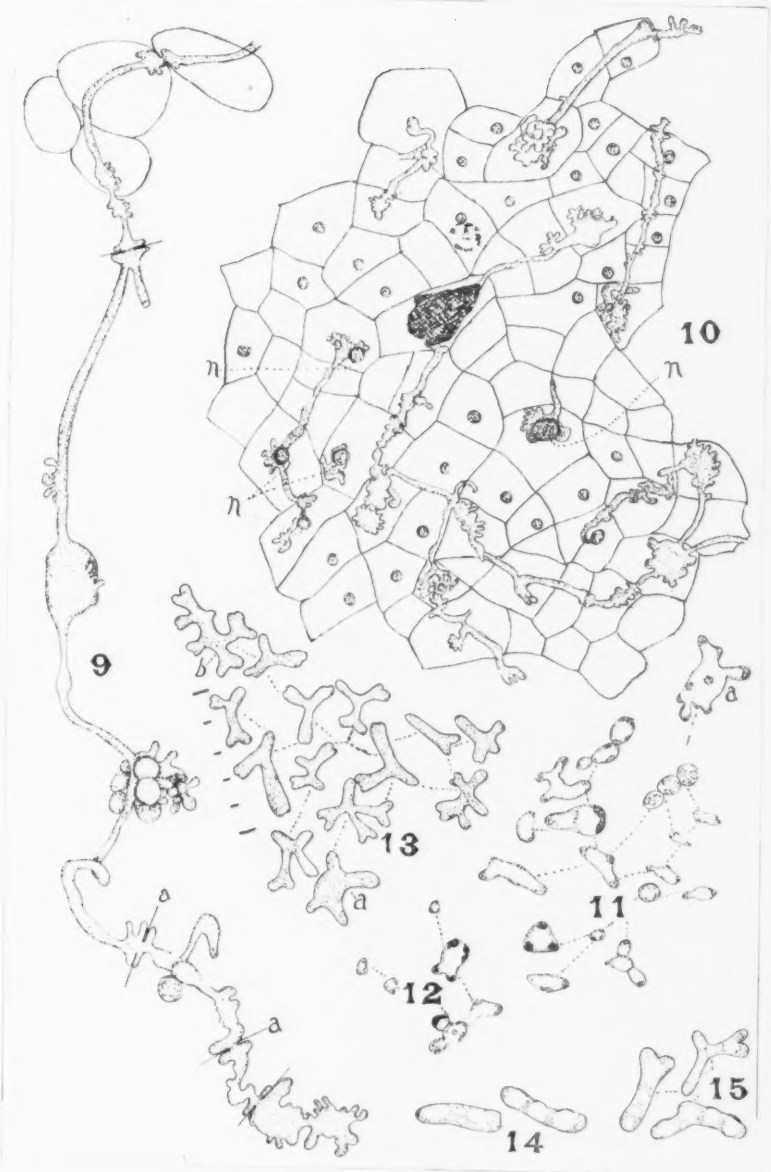

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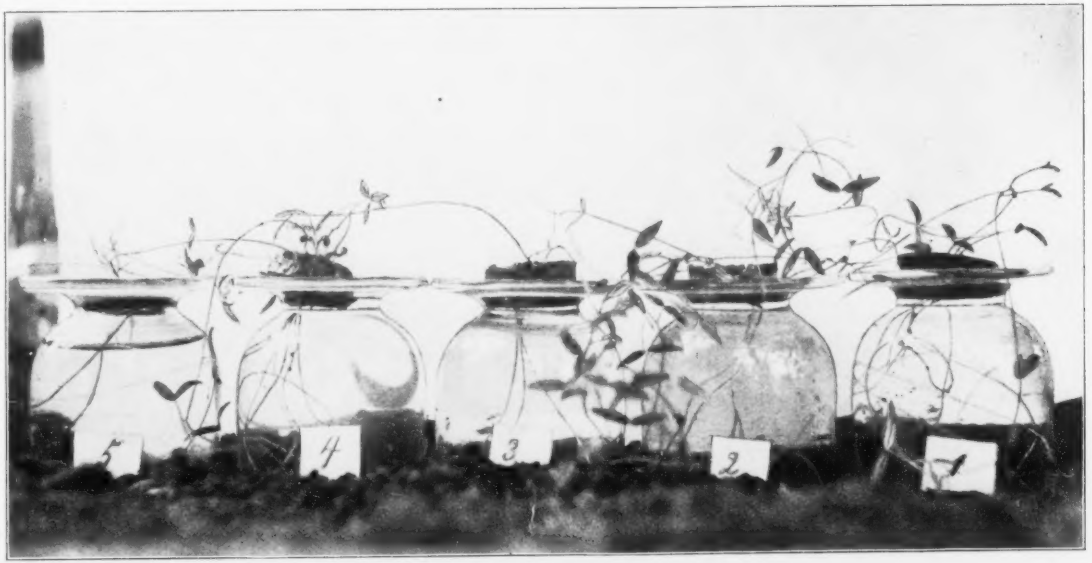

ATKINSON on LEGUMINCUS TUBERCLES.

BOTANICAL GAZETTE

MAY, 1893.

Contribution to the biology of theorganism causing leguminous tubercles.

GEO. F. ATKINSON.

WITH PLATES XII—XV.

The study of the tubercles of the Leguminosæ involves several fields of investigation. One is concerned with the economic phases of the subject, the acquisition of nitrogen from the air by plants and the enriching of the soil by decay of the plants or by the setting free of nitrogenous substances, upon the decay of the tubercles, which have been fixed by the aid of certain organisms within the tubercle. This phase of the subject is of such practical importance that it has been treated of very widely in agricultural papers and is in a general way better known than the other aspects of the subject.

Another field of investigation is a chemico-physiological one and relates to the question of the method of acquisition of nitrogen by plants, and the physiological processes involved.

Still another field of investigation is the biology of the subject. This is concerned primarily with the induction of facts relating to the morphology, development and kinship of the lowly organism, to the structural features of the tubercles and the relation of the two symbionts. It is beyond the scope of the present paper to treat of the economic and chemico-physiological aspects of the subject. The discussion will be confined mainly to the biology of the organism, since this part of the subject is the least understood and there exist so many conflicting views concerning it. The structure and development of the tubercle is better understood and will be referred to only incidentally as is found necessary in dealing with the relations of the two organisms.

Original investigations.

Four years ago while engaged upon a study of the nematode root-galls[1] of various cultivated plants, I was led to investigate with some care the morphology and anatomy of the leguminous tubercles and their contents in order primarily to discover differential characters which could easily form the basis for the accurate separation of the tubercles from nematode galls which frequently occur on the same roots. A brief résumé of the results of the leading investigations up to that time was presented along with the results of the root-gall study.

The subject became to me so fascinating at that time that during the seasons of 1891 and 1892 considerable attention was given to further personal examination of the subject, and to familiarizing myself with the literature relating to the morphology of the organism. It soon became apparent that while nearly all investigators agreed in regard to certain morphological phenomena presented in connection with the anatomy of the tubercles, several conflicting interpretations were given of them, and nearly as many views were entertained respecting the nature of the organism. For this reason, and also because no American observations had been recorded at that time, I was led to undertake some personal investigations of the biology of the organism. During the winter of 1891-2, therefore, preparations were made for this work. It has seemed best to first present here the results of my own study, and to follow this with a historical résumé and a comparison of the conclusions reached elsewhere.

The tubercles are quite prominent lateral outgrowths of the roots and present varied forms, the types of which are associated with different groups of the Leguminosæ, though the limits of these groups do not correspond in all cases with those of genera.

In *Vicia sativa*, from the tubercles of which pure cultures of the organisms were obtained, they are digitate, and either simple or forked di- or tri-chotomously. They vary in length from a size equal to their diameter to 4^{mm} to 7^{mm}. Plate XII illustrates several roots of *Vicia sativa* reproduced from photographs. It will be observed that the tubercles stand nearly at

[1] A preliminary report upon the life history and metamorphoses of a root-gall nematode, *Heterodera radicicola* (Greeff) Müll. and the injuries caused by it upon the roots of various plants. Science Contrib. Vol. I. no. 1. Ala. Agr. Exp. Station, Dec. 1889.

right angles to the roots and that there is no taxic law governing their position on the roots. On some of the plants they are crowded on the root near the union with the stem. In such cases infection took place profusely at a very young stage of the seedling. On other plants very few tubercles are found near the union of the root and stem, but they are widely distributed over the root system. The roots illustrated in plate XII show this variation well.

When the tubercles are young or growing rapidly they are of a delicate flesh color, presenting a mealy aspect from numerous cells of the cortical parenchyma which are being pushed apart from their union by the rapidly growing meristematic tissue of the tubercle. When the tubercles have attained some size and age the older portion presents a light brown color in contrast with the flesh colored distal portion. Some of the other type forms of the tubercles are represented in *Medicago denticulata*, *Dolichos Sinensis*, and *Trifolium*.

In *Medicago denticulata* they are remarkable both for their size and compact botryose ramification, attaining a diameter frequently of 1^{cm} to 1.5^{cm} and bearing a striking resemblance in external appearance to the root-galls of *Alnus* which however are produced by an entirely different fungus of the genus *Frankia*, as described by Brunchorst[2], Möller[3], and the writer[4]. In *Dolichos Sinensis* the tubercles are irregularly rotund bodies. In *Trifolium procumbens*, *Carolinianum*, and other species they are cylindrical-clavate.

Vicia sativa matures its seed during the months of May and June in central Alabama[4a]. During the sunny part of dry days the mature pods by unequal contraction are suddenly split apart and the seed cast to a considerable distance. During the summer, autumn, and early winter months the seeds are gradually buried in the soil, so that during mild weather in January and February they germinate and grow so luxuriantly as to afford in some cases valuable winter grazing. The temperature of the soil at this time is sufficiently warm to permit the growth of the tubercle organism, and at an early stage

[2] Ueber einige Wurzelanschwellungen, besonders diejenigen von Alnus und den Elæagnaceen. Unters. Bot. Inst. Tübingen. II. 151.

[3] Beitrag zur Kenntniss der *Frankia subtilis* Brunchorst. Ber.d.deutsch.bot. Gesellsch. VIII (1890). 215-224.

[4] The genus Frankia in the United States. Bulletin Torrey Bot. Club. XIX. June, 1892.

[4a] When this study was begun the writer was connected with the Ala. Polytechnic Institute, Auburn, Ala.

it is easy to find numerous rapidly growing and fresh tubercles. The temperature of the soil is sufficiently low, however, to retard the growth of many soil organisms, so that the outer surfaces of the tubercles do not contain such numbers of bacteria as are met with in the warm days of late spring. The early season then is the more favorable for the separation of the organism.

As soon as the plants had attained sufficient size to gather a small quantity of the vines an infusion was made and added to agar-agar peptone broth to afford a suitable medium in which to transplant the organism.

Method of obtaining pure cultures.

To separate the organism without contamination young but fair sized tubercles were selected. These were washed carefully and finally rinsed in distilled water and allowed to drain until the surface was not wet. A razor was then heated, not to redness, but to such a degree as would probably kill all adherent germs. A small segment was then removed from the end of the tubercle with a quick stroke of the razor so that the heat would not kill the organisms in the tubercle. As the razor was passing through the back was lifted during the stroke in order to lessen the possibility of dragging germs from the outside into the center. Then a flamed, double, sharp-pointed platinum needle was thrust into the cut end, twisted part way around, withdrawn, and with this a puncture was made in the vetch agar in culture tubes. The first transplantings were made in March, 1892, ten or twelve culture tubes being inoculated. Some of these proved to be contaminated in a few days, possessing common forms of *Bacillus, Micrococcus* and *Bacterium.* Others showed no evidence of growth before eight to ten days, when there appeared in a few of the culture tubes a small whitish, glistening, pearly colony at the surface of the point of inoculation. In a week more this growth had increased, having a surface extent of 2^{mm} to 3^{mm} and presented a slight convexity of surface. The growth did not extend perceptibly to more than 2^{mm} to 3^{mm} deep in the medium, but at a subsequent time spread over a greater area upon the surface. The slow growth of the organism in the artificial medium caused it to be looked on with suspicion. When the growth had attained such proportions that a small quantity could be removed without destroying the entire colony, an examination was made of the organism.

The individuals are held rather firmly together by a viscid excretion so that portions of the mass appeared "stringy" as the needle was lifted from it. They are very minute yet quite characteristic in form, and as they appeared in artificial culture are easily distinguishable from other organisms. In general appearance many of the individuals resemble some yeast, or low torula forms, yet they differ in shape and in being much smaller than any known yeast. Although so small the individuals vary greatly in size and present remarkable variations also in form. In size they vary from 0.2μ to 2μ or 3μ, and in form from a triangular outline to oval, elliptical, oblong, torulose, or variously forked and amœboid forms, as represented in figures 11 and 12 of plate XIV. A nearly homogeneous protoplasm occupies by far the larger and more central portion of the organism, while the granular protoplasm is near the periphery, but usually collected or bunched at certain points near the interior surface of the wall, these being connected by thinner sheets or threads of similar protoplasm. After some study of the different forms and observations in cell cultures it was found that these masses of granular protoplasm are almost invariably located at the growing points of the individuals, and it would be quite possible within certain limits, perhaps, from a rather simple individual to determine the more complex form it would assume at a later stage. Figures 11 and 12 represent clearly the relation of the granular protoplasm to the growing points of the individual. In figure 11*a* the individual is of an amœboid form, and the granular protoplasm bunched near the center of the figure represents in reality a downward growing process at this point, which could easily be seen by changing the focus of the microscope.

In cell cultures which were started by inoculating melted vetch agar, after a period of incubation of five to ten days there appear minute flocculose areas of growth at different points in the medium. These increase in extent until colonies of varying size occupy the medium.

The same organism has also been obtained in cell cultures of vetch agar by transplanting to them a thin section of the inner part of a tubercle, after the cortex had been removed, of course observing aseptic precautions.

In from six weeks to two months the organism was transplanted into fresh culture media to prevent death from lack of nutrition.

Inoculation experiments.

During the month of April, 1892, an experiment was put in progress to determine the relation of this organism to the orientation of the tubercles. Vetch seeds which had been gathered the previous year for this purpose were planted in two different vessels. These vessels contained sand from which the soil had been washed. The sand was saturated with distilled water to which was added a small quantity of kainite and acid phosphate, and the vessels were then steam sterilized two hours a day for three successive days. The sand was so saturated with water that it was covered with a thin layer. This was necessary in order to provide sufficient moisture for the hard dry vetch seed to germinate. After the plants had attained a length of 5^{cm} to 10^{cm}, organisms from the culture tubes of vetch nutrient agar were transplanted to vessel no. 1. An attempt was at first made with a fine needle to inoculate roots at certain points but the quantity of moisture in the sand quickly dispersed the organism over all parts of the surface of the sand. Vessel no. 2 was held as a check. There were from fifteen to twenty plants in each vessel.

During a period of a month the plants in both vessels made slow growth, being kept in a window in the laboratory, and a large bell jar covering both rested upon an uneven surface so that the air would not be kept too moist. At the end of this time a few plants in vessel no. 1 were examined and found to possess several small tubercles each. The tubercles were very much smaller than those developed in nature, as were also the vetch plants, owing probably to the artificial conditions of environment. These tubercles on the plants in vessel no. 1, developed as a result of artificial inoculation, formed the material from which a study of the organism within the tubercle was made. The examination and study of these tubercles and the organism within extended over a month's time, and it was found at the close of this period that only a few of the plants in vessel no. 1 escaped inoculation. In vessel no. 2 not a single tubercle was developed.

In July of the same season a second inoculation experiment was conducted, the vetch plants this time being grown in water culture. Five glass vessels, capacity about one pint, having a rather small neck, were fitted each with a cork which would float on the water when this rose above the neck of the vessel and partly filled the basin formed by the flaring edges.

When the water became low the cork would rest in the neck of the vessel. The corks were perforated to admit the young roots of the vetch seedlings. Mineral fertilizers consisting of acid phosphate and kainite were added to the water and the vessels were then thoroughly sterilized. Vetch seeds were germinated on moist sterilized sand, and when the seedlings were of sufficient size for the young root to reach the water, the plant was placed in the perforation of the cork. Three plants were transferred to each vessel. In a few days when it was assured that the plants were all growing nos. 1 and 4 were inoculated by transplanting with a looped platinum needle a quantity of the organisms from the pure culture to the roots of the seedlings in the perforated cork. This experiment was also successful and though the tubercles were small they were so distinct as to be readily photographed. The entire experiment was then photographed and is represented in plate XV. Two tubercles can be seen in each of jars no. 1 and 4. The checks, nos. 2, 3 and 5 possessed no tubercles. The organisms used in this second inoculation experiment were of the fifth transplanting in the culture tubes. These results would seem to afford pretty conclusive proof that the organism described above from cultures in artificial media the specific microsymbiont of the vetch tubercles.

Mode of infection.

As stated above, the material which formed the basis for the study of the organism in its natural relation to the tubercles was obtained from the inoculated plants in the first experiment, which were grown in sand culture. Roots possessing very young tubercles were mounted in water for microscopic examination of the surface. At the youngest stage examined the tubercles presented only a low convex lateral protuberance of the surface on one side as shown in figure 4 of plate XIII. The root still possessed numerous normal root hairs some of which also occupied the surface of the young tubercle. In many instances at this young stage one of the root hairs presented a very peculiar appearance. This is represented in figure 4, plate XIII, and the same root hair is drawn to a larger scale and from two different points of view in figures 5 and 6. The very tip of the hair is coiled once in a close spiral and the end has undergone further change in shape by being bent in the form of a shepherd's crook or a walking stick. The organism usually enters at the end of the root

hair, and must exert a peculiar and powerful influence in order to bring about this change in form.

Form of the microsymbiont in natural environment.

In the protoplasm of the root hair, which is a more suitable pabulum than the nutrient vetch agar, and also in point of view of economy in nature, the organism does not grow indifferently as to direction but extends straight away down the root hair in its effort to reach the cortical parenchyma of the root. Probably the macrosymbiont also exerts some influence on the direction and definiteness of the growth of the microsymbiont.

In figures 5 and 6 the organism presents the form of a thread or non-septate hypha, in size from one fourth to one third the diameter of the root hair. It describes a somewhat flexuous course and occasionally, as shown near the outer end in figure 6, broadens slightly at places presenting a nodulose appearance. Rarely the organism enters the root hair nearer the proximal end as shown in figure 7. In such cases the end of the root hair is not deformed. The ends of the root hairs frequently become deformed and variously curved from other causes, but when it is due to this organism its presence can quite easily be noted.

The contents of the infecting hypha are homogeneous and the entire thread presents a gleaming aspect which enables one to readily distinguish it from the contents of the root hair.

When the organism has once entered the cortical parenchyma its manner of growth becomes quite different, since it is coming more directly within the arena of its real activity and more directly under the influence of the macrosymbiont. By this time it has already stimulated the root tissues at that point to greater activity and a meristematic growing point arises about it within the cortical parenchyma. Frequently as the hypha passes through the cell walls it first broadens out in the form of a disk over the surface of the wall at this point, the portion of the hypha which passes through the cell wall being very slender, and upon reaching the other side of the wall it again broadens out into a disk. A lateral view presents the appearance shown in figure 8, a section of the young tubercle containing the infecting hypha. This is better shown in figure 9, the cell walls being represented in some cases by a straight transverse line. This does not occur at the passage

of all the cell walls, but it is of very common occurrence. As represented in figure 7 the hypha sometimes enlarges within the center of the cell lumen very near the epidermis. Farther within the tissue of the tubercle the enlargement of the hypha within the cell lumen is of very frequent occurrence.

The surface of these enlarged portions within the cell lumen is usually marked by a number of protuberances in the nature of buds. These buds present various forms, being either spherical, oval, pyriform, clavate, cylindrical or forked. Soon after entering the root the hypha branches. Some of these ramifications continue toward the center of the root until they reach the endodermis, but do not pass beyond. Others take a lateral course, and from these other ramifications extend outward, and as the tubercle grows in length some are directed radially from the axis of the root and grow in an opposite direction from the course pursued by the infecting thread. Thus the entire inner portion of the tubercle is traversed in a labyrinthine fashion by the ramifications of this organism. A portion of the center of the section shown in fig. 8 is more highly magnified and illustrated in detail in fig. 10, plate XIV. It is a very common thing for the hypha in passing the lumen of the cell to approach the nucleus, enlarge and partly surround it, as shown in figure 10. In many cases the nucleus seems to be stimulated so that it becomes larger than the nuclei not in contact with the hypha.

In making the section represented by figure 8, the infecting thread was cut off along with the root hair at the surface face of the tubercle and appeared in an adjacent section. This is mentioned merely to account for the absence of the root hair containing the infecting thread in that figure. These tubercles produced by inoculation in artificial culture were far superior for studying the form of the organism in the tubercle to those developed in the soil. The food and conditions for growth for the vetch being inferior to those in its natural environment, the protoplasm was not developed so profusely in the tubercle and therefore presented a more favorable opportunity for staining and definition. Violet dahlia, first suggested by Laurent[5] for the tubercle hyphæ, was used in making the preparations.

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[5] Recherches sur les nodosités radicles. Ann. de l'Inst. Pasteur, v (1891). 105–139.

While the organism does not pass the endodermis, its influence upon the hypertrophy of the tissues extends to the endodermis and the tissue of the central cylinder on that side.

(*To be continued.*)

Cornell University.

The genus Corallorhiza.

M. B. THOMAS.

WITH PLATES XVI AND XVII.

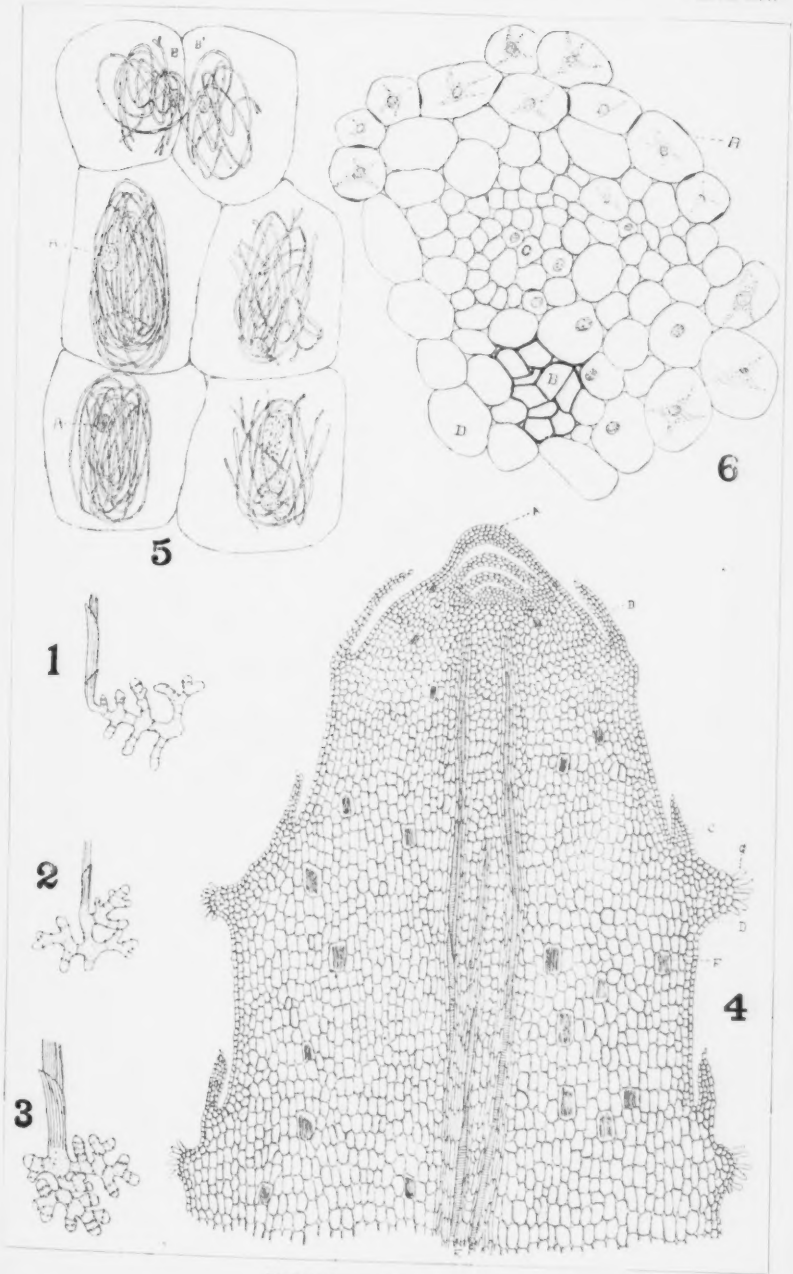
The genus Corallorhiza contains twelve recognized and well defined species with widely varying habitat, being found in Europe, Asia, United States and Mexico.

Four species are found in Northern United States; *Corallorhiza innata* R. Brown, *C. odontorhiza* Nutt., *C. multiflora* Nutt. and *C. striata* Lindl. Of these C. multiflora has the widest range and is the one found in greatest abundance.

The parts above ground have been quite thoroughly studied and the structure is generally well understood, but the parts below ground certainly afford an opportunity for much profitable investigation. The plants of the genus are brownish or yellowish herbs, without chlorophyll, except a little late in life, and in C. multiflora they often reach the height of eighteen inches.

The parts underground are usually described as being "much branched and toothed coral-like root-stocks (probably root parasitic) sending up a simple scape, with sheath in place of leaves, and bearing a raceme of rather small, dull-colored flowers."[1] From the rather striking characters of the stem and flowers it might be expected that the plant would exhibit several marked deviations from the regular phenomena of growth and development, and such is indeed the case. The coralline root-stock which the plant possesses has many variations from the regular type of the underground stem of monocotyledonous plants. The vascular system is represented by somewhat modified collateral bundles which are confined to the center of the stem; these are small and usually quite rudimentary. The whole vascular system is

[1] Gray's Manual, 6th edition.



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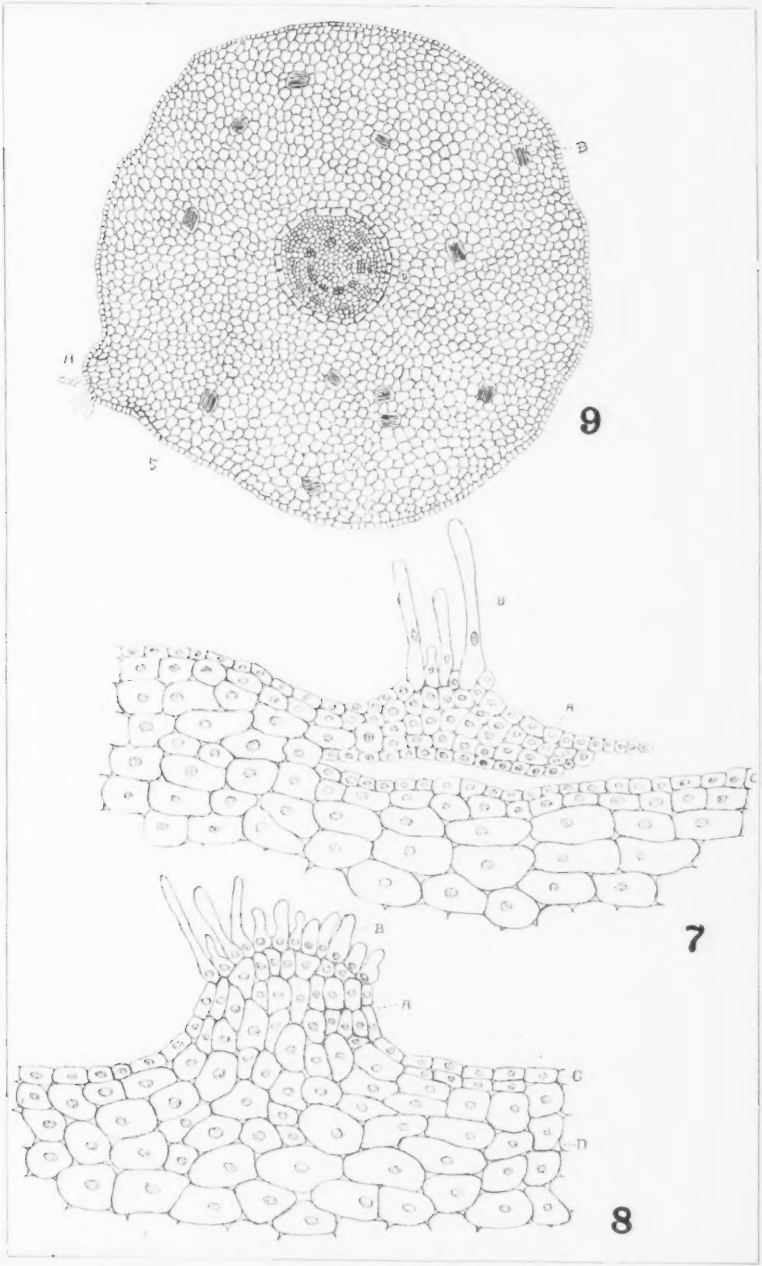

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surrounded by a sheath of collenchyma which gives the fibro-vascular tissues somewhat the appearance of the radial bundles of roots. The arrangement of bundles inside the sheath is as one might expect, usually irregular, but in each individual bundle the phloem occupies the peripheral side.

At the apex of the stem we find about the normal arrangement of parts. The leaves originate near the apex as lateral outgrowths in acropetal order. The primary meristem of the growing point is very active and several immature leaves with those just forming cover the apex.

The tissue of the leaf is perfectly continuous with that of the stem. The foliar bundles are very small and merely pass up to the base of the leaf, which undergoes no differentiation but simply breaks away and there remains a ring or scar in its place on the stem. In the depressions between these rings are found papillæ, which, on the average, are 0.2^{mm} high, and 0.6^{mm} in diameter. On these are borne the trichomes, which are often longer than the height of the papillæ. By means of these papillæ the root may cling tenaciously to any substance with which it may be in contact. Trichomes are often developed on the portions of the leaf-scars that may remain attached to the stem. They are quite large, thin walled, and contain protoplasm with a very large nucleus.

The plant is said to be a parasite, but the weight of evidence seems to strongly contradict such a supposition. Although by means of these trichomes the plant may cling to the roots of other plants, yet repeated search has failed to show any organic connection with them. The epidermis of the root-stock is much broken up by the numerous leaf scars and papillæ but it presents the ordinary characters of a true epidermis. The cortex is of the usual nature and contains many large cells with raphides. It may be possible that the plant does derive some of its nourishment from the roots of other plants to which it clings by means of its papillæ with their trichomes, yet these papillæ are found equally on all parts of the root-stock, and that too on plants which are in no way connected with any other living plant; while those grown in a jar of ordinary soil, free from the roots of all other plants, thrive equally well with those in the woods.

The question at once presents itself, how does the plant elaborate its fluid without the intervention of chlorophyll, especially since in the autumn there is a ring of cortical tissue about the fibro-vascular system the cells of which are filled

with starch, while the remainder of the cortex toward the epidermis contains a considerable quantity of it.

When first studying these stems it was observed that the cell contents of the cortical tissue stained a *dark* purple with hæmatoxylin and often a brownish hue was secured. As this did not represent the usual reaction, it seemed that something extraordinary existed in the cells, and upon further examination it was seen that their cell contents consisted of a small mass of protoplasm completely surrounded and permeated by a great number of septate hyphal threads and these were often traced to similar ones outside of the stem. The latter were somewhat larger and always presented a much denser structure. At first it seemed that the threads might be accidental and due to the presence of some parasite that had attacked the individual plant, but later they were found in the stems of plants obtained from various parts of the country.

The hyphæ are confined to a certain region of the stem and are seldom found within 3–4^{mm} of the tip. The cells nearest the tip, in which they first appear, contain but a few, and it is here that their structure can be best studied. Farther back from the tip the threads increase in abundance in the cells and become very much smaller until they seem to be finally absorbed by the cell protoplasm. The whole assemblage then assumes a granular character and forms with the original cell contents a homogeneous mass. The action of the nucleus is very certain as it responds to the presence of these threads by enlarging, and thus showing an increase in the activity of the cell. Very few of the threads are ever found in the epidermal layer, but they pass through this into the cortex beneath. The few that are in the epidermal tissue partake of the nature of those outside, while just beneath a marked difference is seen.

With a magnification of 2,000 diameters the threads are seen to be a cylindrical tube with walls of a distinctly laminated structure, septate and the outer surface in many cases covered with protuberances. The central cavity of the thread is filled with filamentous masses of protoplasm of a granular character. The hyphæ branch freely and often seem to radiate from a common center which may be the nucleus of the cell.

The cell walls are pierced readily and the threads can be traced through several rows of cells. In proportion to the number of hyphæ present the walls are little punctured as the

great mass of threads is confined to the interior of the cell and they are seldom found in the intercellular spaces. The tissue of the stem is most thoroughly permeated with these hyphæ, and every cell outside of a narrow zone around the plerome, which so often contains starch, and back 2–3^{mm} from the tip, is filled with them. The tissue exhibits nothing that would in any way seem to indicate that the presence of these hyphæ was anything other than beneficial and there can be no doubt of there existing a true symbiotic relation.

The large amount of starch often found in the rootstock cannot be due to the decomposition of CO_2, for chlorophyll is wanting; but it is a derivative of those chemical compounds which have been dissolved and taken up by the hyphæ from the remains of dead plants. The ash constituents and some of the nitrogen compounds may be taken up from the soil by the trichomes and the nitrogen used in the formation of proteid substances for the plant, while the trichomes in contact with old leaves and other humus substances no doubt secrete a ferment and absorb the products which are in solution. This action with the symbiotic relation existing in the plant would give it two methods of obtaining plant food. From the structure of the plant and the abundance of the hyphæ the latter condition must furnish it its greatest source of supply.

Instead of being a root parasite, as has been supposed, the plant depends chiefly on the symbiotic condition for its food and this is taken by the hyphæ from the decaying vegetable matter about. If the plant was once a true parasite the roots have degenerated and finally disappeared, for no roots are found on the plant. This condition exists in an equal degree in all of the species of Corallorhiza yet examined.

It should be stated, however, that hyphæ have been found in the roots of all of our North American Orchidaceæ yet examined (more than forty species), but only in a very limited degree, apparently not enough to materially affect the normal conditions of growth and development; although some varying conditions due to the presence of these relations have been observed, which are constant through the whole group. Endotrophic mycorhiza that pass their whole life course in the part of the plant below ground do no doubt exist in all of the Orchidaceæ. The genus Corallorhiza, in the abundance of this condition, is far removed from the other members of this order.

It is not necessary to give a complete bibliography of the work done on the subject of symbiosis. References to the more important articles can be found in the paper of A. Schneider.[2] The principal papers of B. Frank, who has no doubt done more than any other observer on this subject, can be found in the Berichte der deutschen botanischen Gesellschaft, 1890, 1891, and 1892.

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EXPLANATION OF PLATES XVI AND XVII.

Figs. 1, 2. Base of aeriai and subterranean stems of *Corallorhiza innata* R. Br.

Figs. 3–9. From *Corallorhiza multiflora* Nutt.

Fig. 3. Base of aerial and subterranean stems. Fig. 4. Longisection of root-stock; *a*, old leaf not yet broken away; *b*, *c*, remains of leaves that have broken away; *d*, papilla with trichomes, *g*; *e*, axial bundle; *f*, large cells containing raphides. × 480. Fig. 5. Cells of cortical tissue, with hyphæ, taken from the tip of the stem where they contain but few hyphæ; *a*, enlarged nucleus. Fig. 6. One of the rudimentary bundles of the stem; *a*, general bundle sheath; *b*, xylem; *c*, phloem; *d*, fundamental tissue. × 750 Fig. 7. Remains of a leaf, *a*, with trichomes, *b*. × 750. Fig. 8. Papilla, *a*, with trichomes, *b*. × 750. Fig. 9. Transection of root-stock; *a*, papilla with trichomes; *b*, cell with raphides; *c*, general bundle sheath; *d*, collateral fibro-vascular bundle with an unusually regular arrangement. × 480.

George Vasey: a biographical sketch.

WM. M. CANBY AND J. N. ROSE.[1]

WITH PORTRAIT—PLATE XVIII.

On the first of April, 1872, Dr. George Vasey was appointed Botanist to the Department of Agriculture. For twenty-one years he continuously held this position with credit to himself as well as to the advantage and satisfaction of the government and of his botanical confreres. The life of one who could do this during this time of great botanical activity and advancement must present interesting points to all who are engaged in the study of botany; and it is to satisfy this interest that these notes are written.

[2]Bull. Torr. Bot. Club, XIX, 216.

[1]It is proper to state here that Dr. Vasey had requested Mr. Canby to prepare a sketch of his life and the Editors of the GAZETTE not knowing of this request asked me to gather together what data I could regarding his life. At Mr. Canby's suggestion this article is published jointly as it avoids much duplication. My relations with Dr. Vasey, while most intimate, only extend back to 1888, whereas Mr. Canby has enjoyed an acquaintanceship and correspondence of more than 30 years.—J. N. R.

GEO. VASEY.

It will surprise many to learn that George Vasey was not a native of this country. He was born near Scarborough, England, on the twenty-eighth of February, 1822. In 1823 his parents came to this country and settled at Oriskany, Oneida County, New York, not far from the birthplace of Asa Gray who was then a lad at school. He was the fourth of ten children; and his father, a steady, excellent man, probably did the best he could when he provided him schooling up to the age of twelve. He had been, however, a good scholar and by that time had advanced sufficiently to have acquired some knowledge of algebra and a good foundation in Latin. He now became employed in a store as clerk, in which occupation he continued for several years at Oriskany and the neighboring village of Pleasant Valley. When between twelve and thirteen, he became interested in the study of botany by means of Mrs. Lincoln's "Elements of Botany," a little book well known to the older botanists of the country. Not having the means to purchase this *he copied it entire.* This interest in botany, so early manifested, was throughout his whole life his one great passion. His first meeting with a fellow-botanist is best told in his own words. "I remember well that one day as I was standing in the doorway of the store, I saw a gentleman approaching who stooped down and plucked a flower from the sidewalk. Coming to where I stood he held up the plant and asked me if I knew the name of it. I replied, 'Yes, it is a buttercup.' 'Well,' said he, 'do you know its botanical name'? 'Yes,' I replied, 'it is Ranunculus acris.' This was probably more than he had expected. We entered the store and he talked with me to ascertain how much I knew of botany. This stranger was Dr. P. D. Knieskern, a German physician, a fine scholar, and one of the foremost botanists of that day. He invited me to visit him, which I frequently did and, as I had considerable leisure early in the morning, I soon began to collect and preserve specimens of the plants of the vicinity and finally made frequent trips with the Doctor until I became well acquainted with the flora of the region. Through him I was led into correspondence with Dr. John Torrey and Dr. Asa Gray. I became much interested in the genus Carex which was largely represented in Oneida County and collected extensively, furnishing specimens to Prof. Chester Dewey of Rochester, Dr. Torrey, and especially to Mr. John Carey, then of New York, who afterward prepared the article on the genus Carex for an early

edition of Dr. Gray's Manual. I should also add the name of Dr. H. P. Sartwell of Penn Yan, New York, with whom I made large exchanges. Ultimately my correspondents included also Mr. S. T. Olney of Rhode Island and Prof. Daniel C. Eaton of New Haven, Conn."

When twenty-one years of age, having already graduated at Oneida Institute, he decided to study medicine and for this purpose attended three courses of lectures at the Berkshire Medical Institute, at Pittsfield, Mass., from which he graduated in 1846. While doing this he was obliged to support himself by teaching school. It was during this time that he first made the personal acquaintance of Prof. Dewey, at that time the leading caricographer of the country. Immediately after graduation he spent a few weeks at the College of Physicians and Surgeons, in New York City. It was at this time that he had the advantage of personally knowing the two preeminent botanists of America, Doctors John Torrey and Asa Gray, and from this time they were his life-long friends. About Christmas of this year he married Miss Scott, of Oriskany, and settled at Dexter, New York, where he commenced the practice of his profession. In 1848 he removed with his wife and child to Illinois, where, at Elgin and Ringwood, he spent eighteen years of his professional life. Very early in 1866 his wife's feeble health compelled him to seek the milder climate of southern Illinois, where, however, she soon died, and he did not long remain. Throughout all these years, first in the rich botanical region of central New York, and afterward almost throughout the prairies of Illinois, he had continued the study of his favorite science, making those large and useful collections which have so enriched the older herbaria of our country, and extending his botanical correspondence until it included all the active workers in the science. From the late Dr. Engelmann, especially, he received much aid, and he also came in pleasant contact with a number of active young botanists, among whom were the excellent Mr. Bebb, Major J. W. Powell, now head of the U. S. Geological Survey, Mr. H. N. Patterson and Mr. S. A. Forbes. These gentlemen, with others, such especially as Dr. J. A. Sewall and Prof. C. D. Wilber, were instrumental with him in forming the Illinois Natural History Society, of which Dr. Vasey was made President.

Toward the close of 1867 he was again happily married. His second wife was the widow of surgeon John W. Cameron,

and daughter of Dr. Isaac Barber, of New York. Soon after he met with a crushing financial disaster, largely dependent upon an imperfect title to his property. It was just at this time that Major Powell was organizing his Colorado Expedition for 1868, and he desired to have Dr. Vasey accompany him as botanist. The devotion of Mrs. Vasey, who took entire charge of his young family and of his entangled financial affairs, enabled him to accept this tempting offer. The expedition did not get under way until June, 1868. By the third of July it had reached Cheyenne and he had already collected one hundred and fifty species. On the twenty-first he wrote enthusiastically of his prospects and of the country, speaking of Denver as a "marvel of a place," having "a population of five or six thousand and many good brick business houses!" He returned in December with a splendid collection which has enriched and enlarged several of the best herbaria of the country. He had now wholly given himself up to botanical pursuits. For a year he was associated with Professor Riley in the editorship of the "Entomologist and Botanist," published at St. Louis, and was also curator of the Natural History Museum in the State Normal University of Illinois, which position he resigned to become the Botanist of the Department of Agriculture and Curator of the U. S. National Herbarium, under the Smithsonian Institution. He received this appointment on the recommendation of Dr. Gray and Prof. Henry. When he assumed these duties, the Herbarium, while containing most valuable material, was in poor condition and of little use. Under Dr. Vasey's wise and energetic administration it has become of vast extent and of prime importance. Overcoming by patient effort the lack of appreciation of those in high office who thought it a waste of time and money to advance the sciences which wait upon and promote true agriculture, he finally obtained adequate means to make his division one of the most active and useful in the Department. His first work of general interest was the collection of the woods of American forest-trees made for the Centennial Exposition in Philadelphia. It was only after much solicitation and some difficulty that he obtained a small appropriation for this purpose. This collection contained good specimens of most of the woods of our country, each specimen being accompanied by one or more herbarium sheets, showing flowers, fruits and leaves. It was a valuable

and instructive exhibit and paved the way for a better study and increased knowledge of the forest wealth, with which our country has been so richly blessed and which our people have so wantonly wasted.

But his crowning work was undoubtedly the building up of the great herbarium. In it are preserved the specimens collected in the various government surveys, and to these are added a vast number obtained by exchange and purchase, by gift from foreign governments and by collections from the remoter regions of the United States and Mexico made by the special collectors of the division. The collection of grasses from North America is probably the richest to be found anywhere. Of these alone there are nearly 15,000 sheets. A great part of these he not only named but labelled and mounted; and it is in the study of the Gramineæ as represented in North America that he has done peculiar service to American botany. It will perhaps be a surprise to many to know that before he took up the grasses as a specialty he had collected and studied mosses extensively. Of late years, however, he devoted all his spare time to the Gramineæ.

The result has been that his writings have been most largely upon grasses and forage plants. His most important paper in an agricultural point of view is probably the special bulletin on the agricultural grasses of the United States, published in 1884. This edition was soon exhausted and in 1889 a new, revised, and enlarged edition was published and has been in great demand. He published several other bulletins treating of grasses from a practical standpoint, those especially important being numbers 1, 3 and 6, of the Botanical Division. He contributed numerous scientific papers on grasses to botanical journals. In 1891, at the earnest solicitation of many correspondents as well as to carry out a long cherished wish of his own, he began the preparation of a monograph of North American grasses. This was prepared amidst the pressure of many official duties and perhaps was somewhat hastily published. The first part was issued February 25, 1892, and the second was being rapidly pushed but was not finished at the time of his death. The work, however, is so advanced that we may hope for its early completion and publication. But larger and more important than this was his Illustrations of North American Grasses. The first volume, issued in two parts, treats of the "Grasses of the

Southwest," and the second volume of the "Grasses of the Pacific Slope." The second part of the latter is still in press. A few months before his death, Dr. Vasey began to describe the new but unpublished grasses which had been accumulating in the herbarium for many years. This work was completed less than a week before he died.

In the year 1888 Dr. Vasey succeeded in bringing to the attention of Congress his long cherished scheme of establishing grass experimental stations in the arid and semi-arid regions of the west. With the assistance of the late Senator Plumb and others, an annual appropriation of $40,000 was obtained for the Botanical Division. This allowed for considerable increase in the scientific force at the herbarium and the sending out of botanical expeditions. The chief object of this appropriation, however, was the establishment of the Grass Experimental Station at Garden City, Kansas. This work has been directly under the charge of Dr. J. A. Sewall. It was Dr. Vasey's idea to experiment here with both native and introduced species for the purpose of obtaining grasses and forage plants adapted to the region west of the 100th meridian where irrigation is not practicable. These experiments have all been made without irrigation and the result of the four years work has justified the outlay in money and has confirmed the wisdom of Dr. Vasey's plan.

Dr. Vasey's name has been twice used in forming generic names; first for a grass named Vaseya by Prof. Thurber. This, however, was properly merged in Muhlenbergia. Recently, Prof. Cogniaux has named a Cucurbitaceous plant Vaseyanthus. Many species also bear his name.

In 1864, Dr. Vasey received the degree of M. A. from the Ill. Wesleyan University. He was a member of the Geographical Society of Washington and a charter member of the Biological Society of the same city. Long a member, in 1889 he was made a fellow of the American Association for the Advancement of Science. He was made an associate fellow of the American Academy of Arts and Sciences on June 15, 1892. He was the joint representative of the Smithsonian Institution and the Agricultural Department to the Botanical Congress at Genoa in 1892, at which he was made one of the Vice-Presidents.

Dr. Vasey was a quiet and dignified gentleman of most kindly feeling and pleasing address. Those connected with him in his work speak with warmth of the pleasant relations

he sustained with them. While conscientiously efficient and firm in his duties, his sweetness of disposition made him beloved by all. To the narrowing circle of the older botanists who have so long known him and cherished his friendship, his loss comes with peculiar force. Few of the American botanists now living have been in touch with a larger circle of friends and correspondents; and some of these have been and always will be pre-eminent in the science.

Dr. Vasey died at Washington on March 4, 1893, after a severe illness of only three days. He leaves a widow and six children.

The following resolutions were passed by the officers of the National Museum at a meeting held on March 6th:

In the death of Dr. George Vasey the National Museum has lost a faithful and efficient officer, and the science of botany an able and indefatigable worker. As botanist of the Department of Agriculture and curator of the National Herbarium for twenty-one years, Dr. Vasey's name has become known to all botanists throughout the world and his contributions to science form an indispensable part of the working library of every botanist. His familiarity with the flora of all parts of the United States, especially with the plants of the great west, was unrivaled and caused his opinion to be sought and respected upon all critical questions relating thereto. He was the recognized authority on this side of the Atlantic in the important department of grasses, and his publications relating to these have great economic as well as scientific value.

Dr. Vasey was uniformly gentle and kind, manifesting a warm interest in the progress of younger botanists and beginners, always ready to give his valuable time and counsels to those who went to him for assistance, and many who are now well known in the science owe their success in large part to the encouragement and stimulation received from him. In this way the circle of his influence was much wider than would be naturally inferred from his quiet life and long confinement to a single post of duty.

To the world at large Dr. Vasey was distinguished for his modest and unobtrusive character, his kindly disposition, and his genial manners. A model husband and father, an estimable neighbor and a good citizen, his loss will be deeply felt by all who knew him. Therefore,

Resolved, That the sympathies of the officers of the National Museum and Smithsonian Institution be extended to the widow and family of the deceased, and that a copy of this minute and resolution be transmitted to them.

Similar resolutions were passed by the scientific corps of the Department of Agriculture.

The following bibliography was prepared by Miss Josephine A. Clark, of the Botanical Division, Department of Agriculture.

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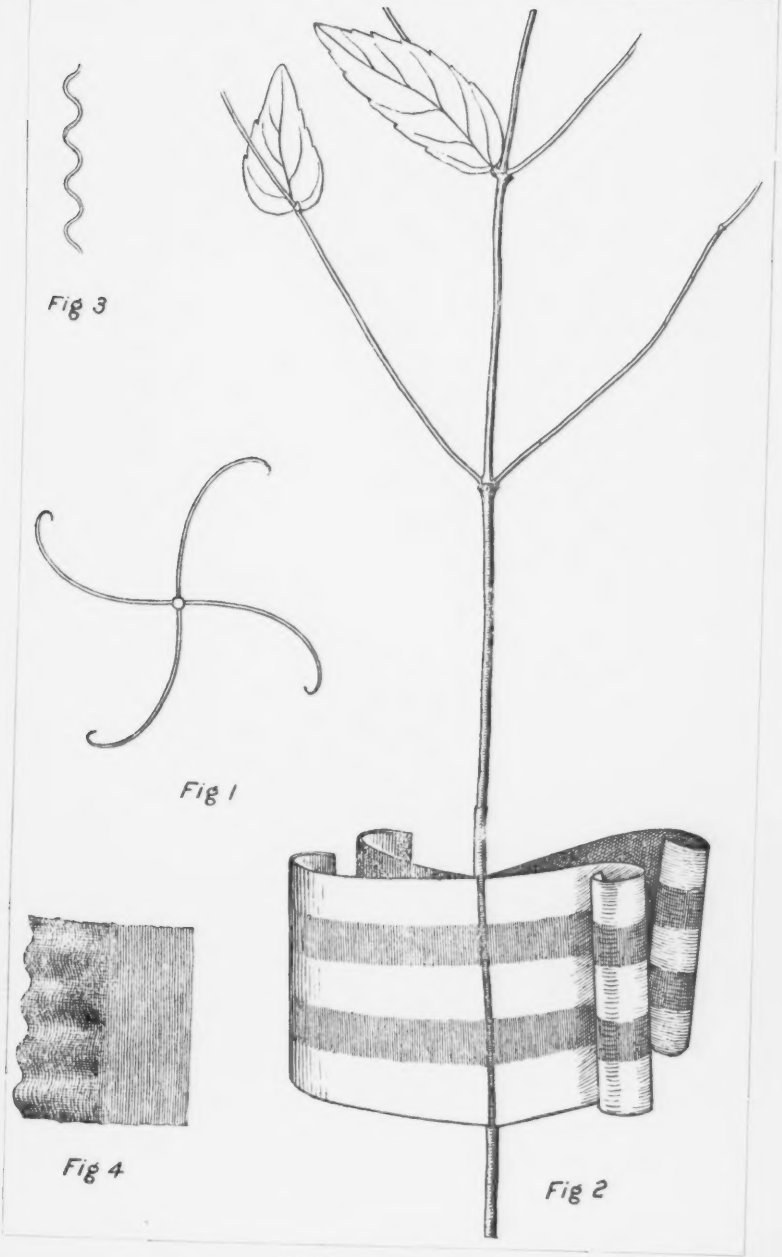

WARD on DITTANY.

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Report of the botanist[2]. (In U. S. Dept. of Agric. Rep. of the Sec'y for 1891. pp. 341–358. Washington, 1892.)

Wilmington, Del. and Washington, D. C.

Frost freaks of the dittany.

BY LESTER F. WARD.

WITH PLATE XIX.

One bright, crisp, frosty morning (Dec. 5, 1892), as I was taking a delightful ramble with my congenial friend Mr. Victor Mason and following the pleasant road that leads from the little Virginia village of Accotink toward the tomb of Washington, some white objects looking like icicles close to the ground on our right along the border of a pine wood arrested our attention. After remarking a number without stopping to inspect them they presently grew so numerous and exhibited such a uniformity that the scientific instinct could no longer be restrained and we turned aside to satisfy our curiosity.

We found that they were in truth nothing but ice, but that instead of icicles they were veritable freaks of frost. Every one was firmly attached to the stem of a small herbaceous plant which had succumbed to the season but still stood erect. The attachment was always close to the base, often at the very ground, sometimes an inch above. At a distance the frost-works had the appearance of cylindrical masses, but one need not come very near to see that such was not the case. In fact they really consisted of several thin foils or wings from one to three inches in width, firmly attached by one edge to the stem of the plant, thus standing in a vertical position. From this attachment each of these little ice sheets projected out horizontally or with a slight upward tendency, not straight and stiff, but gently and gracefully curving or coiling into a beautiful conch-like roll at the distal margin. There were always several of these, usually three, four, or five, all attached

[1] Part 2 of this work will be issued June 1, 1893.—J. N. R.

[2] Report of the botanist for 1893 will be issued in June, 1893.—J. N. R.

to the same vertical portion of the stem but at regular intervals around it like the paddles of a flutter-wheel, but all curving in the same direction after the manner of a turbine wheel. Thus, where there were four they stood with each pair opposite, as in the accompanying cuts, of which fig. 1 represents a cross-section and fig. 2 a side view. The amount of curving varied considerably, and the coil sometimes filled up most of the interval between the plates giving the object a compact appearance. The ice was white, opaque, and singularly light, as if consisting of congealed froth, but in all cases the scrolls bore horizontal stripes like those of a flag, resulting from degrees in the whiteness, varying from alabaster to nearly transparent. These stripes added greatly to the beauty of these singular objects. In some cases the inner margin, instead of being straight was sinuous (fig. 3), giving a fluted character to the base of the wing (fig. 4). Many other peculiarities were noted in these evanescent toys, as holding them in our hands we walked along discussing and admiring them; but as they soon vanished and memory is treacherous, I refrain from further details.

But what propriety is there in publishing this purely physical phenomenon in a botanical journal? Just here is the chief wonder. There grew in the same situation some dozen or twenty small herbaceous plants of about the same general character which would all seem equally liable to exhibit such a phenomenon. There were species of Aster, Solidago, Chrysopsis, Pycnanthemum, Polygonum, Ludwigia, Sericocarpus, etc., etc., and with these in considerable but not specially marked abundance, *Cunila Mariana*. The first frost-works seen were attached to this plant, which we supposed for a while to be an accident; but soon we perceived that such was not the case, and an examination of hundreds of cases revealed the fact that they were exclusively confined to this species. No sign or semblance of them could be found on any other plant. They were, therefore, so far as our observation went, a specific character, and it is this alone which has prompted me to give the above account in the hope that others might be able to confirm or invalidate this induction by a wider one.

This plant, at least in this latitude, persists after frost with all its branches, sear leaves, and empty seed-vessels intact, so that its identity is as complete as it was in midsummer. The bark, which remained firm everywhere else was seen to be

longitudinally split into strips at the zone occupied by the frost-work, but as it could be seen between the several ice sheets, these rifts must have been covered by their bases. In other words, it cannot be doubted that the liquid matter out of which they were formed had passed through these longitudinal openings and been deposited by molecular accretions in the symmetrical forms observed. We inferred from this that they might consist entirely of the juices of the plant, and made the only chemical test in our power, namely, that of placing them on the tongue. The result was wholly negative, as nothing distinguishable from pure distilled water could be detected. As the upper part of the stems was dead and dry and the roots perennial, the conclusion was that the water had by some agency been pressed or drawn up through the cambium layer of the roots from the soil and forced out through these apertures in the bark. The action of frost in the ground might account for the required pressure, and the whole would be thus explainable on physical principles. But it explains too much, since no reason can be assigned why the phenomenon should not be universal and not confined to a single species.

Since making these observations I have been to some pains to ascertain whether any one else has witnessed this phenomenon and thus far have found no record. It is possible that this is the first time that *Cunila Mariana* has been discovered to be a frost-weed. At the time the discovery was made it had quite escaped my memory that *Helianthemum Canadense* behaves in a similar way. That plant is not common in this region and I have not yet had an opportunity to observe it at the proper season. The statement in the first edition of Gray's Manual, 1848, where the name "frost-weed" is given to this species, that "late in autumn crystals of ice shoot from the cracked bark at the root, whence the popular name," repeated in all subsequent editions and copied into many other books, is doubtless founded on earlier recorded observations, but is not found in Nuttall or Pursh. My attention was called to it by Prof. J. C. Arthur, who also referred me to a figure in Mr. Wm. Hamilton Gibson's recent book entitled "Sharp Eyes."[1] This figure is somewhat fanciful, being a vignette constituting the first letter of this chapter of his book and aiming to show all the parts of the

[1] New York, 1892. Article "The Frost Flower," pp. 210–211.

plant in addition to the frost work. Although it is, according to this representation, a much less definite and less beautiful object than our dittany "frost flowers," there can be no doubt that the principle on which it was formed is the same. The author's description of it as "fashioned into all sorts of whimsical feathery curls and flanges and ridges" indicates at once the inadequacy of his figure to do it justice and the close analogy between it and the "frost flower" of Cunila.

We shall probably soon hear of other plants that have a similar habit.

U. S. National Museum.

EXPLANATION OF PLATE XIX.

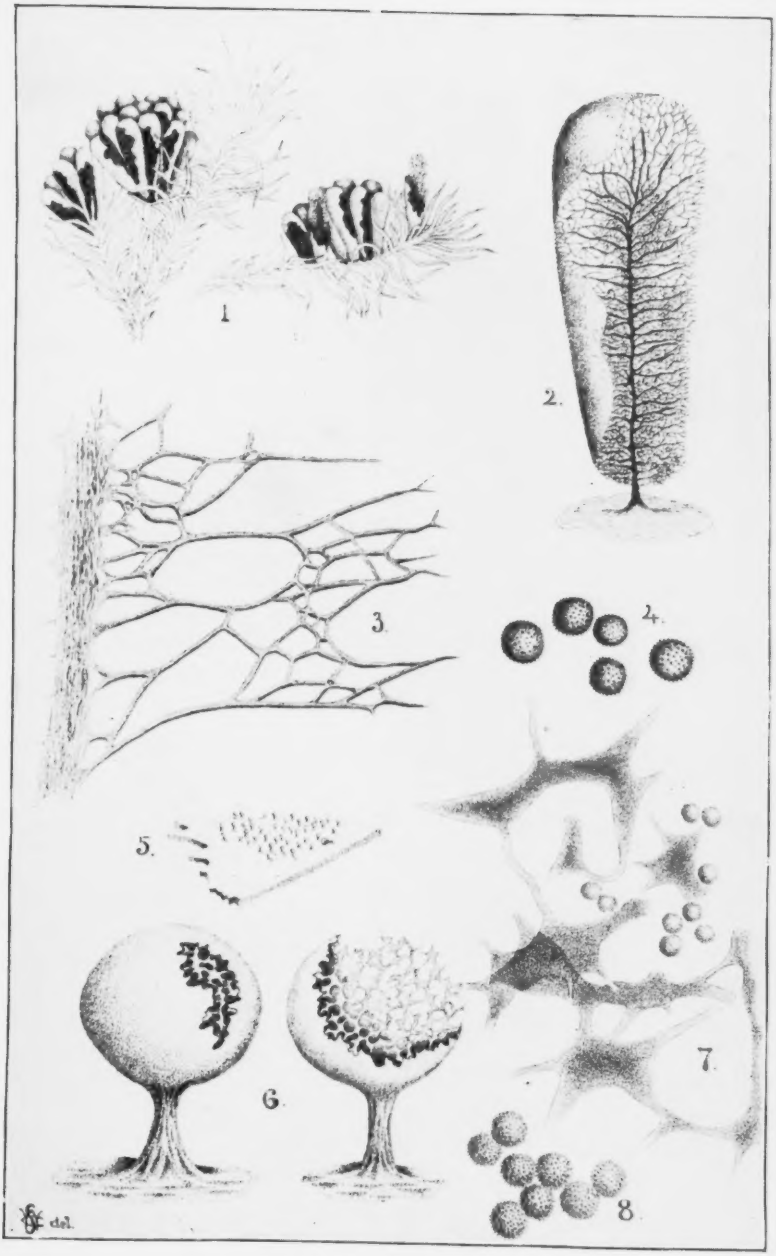
Fig. 1. Cross-section of a four-winged frost-work, generalized. Fig. 2. Side view of same, showing mode and position of attachment to stem. Fig. 3. Illustration of sinuous margin of some of the foils. Fig 4. Side view of same, showing fluted or gathered appearance.

BRIEFER ARTICLES.

On two new or imperfectly known Myxomycetes.—WITH PLATE XX.—**Comatricha caespitosa** n. sp. Pl. XX, figs. 1–4.—Sporangia *densely crowded or cespitose*, rising from a delicate hypothallus. Individual sporangia *very shortly stipitate or subsessile, clavate*, 1–1.5^{mm} high. Sporangial wall grey, iridescent with blue tints, comparatively permanent but finally disappearing. Columella rising to two-thirds or three-fourths of the height of the sporangium, and giving rise throughout its length to the dense, blackish capillitium. Main branches of the capillitium thick at the point of origin, frequently anastomosing and becoming gradually thinner toward the surface of the sporangium; tips pointed, *free, not attached to the wall of the sporangium, and forming no peripheral network.* Spores globose, *distinctly asperate*, 9.6–12.8μ in diameter, pale brownish-violet by transmitted light, blackish-violet in the mass.

On moss, and lichens of the genus Cladonia, Wood's Holl, Mass., August, 1892, *W. A. Setchell.*

This interesting species is characterized by its densely cespitose habit, more or less permanent sporangial wall, and large, asperate spores. The individual columellas sometimes exhibit marked variations from the type, variations which might be taken to indicate abnormal developments. On the whole, however, the principal characteristics of this Comatricha seem to be of definite specific value, if we



STURGIS on MYXOMYCETES.

regard only those characteristics which are common to normal and fully-developed specimens.

PHYSARUM SULPHUREUM Alb. and Schw. Consp. Fung. p. 93. tab. 6. fig. 1.—Plate XX, figs. 5–8.

SYNONYMS.—*Physarum virescens* Fckl. non Ditm. *Physarum chrysotrichum* B. & C. *Physarum decipiens* Curt. *Badhamia decipiens* (Curt.) Berk. *Physarum inæqualis* Peck.

Sporangia scattered, stipitate or occasionally sub-sessile, spherical, 0.8–1^{mm} high. Wall granulated, bright golden-yellow. Stem, when present, one-half to two-thirds the height of the sporangium, blackish-brown. Hypothallus minute, thin, brown. *Columella absent.* Capillitium rather dense, composed of *large, angular nodes, completely filled with bright yellow granules of lime,* and connected by very short, delicate, colorless internodes destitute of lime. Spores globose, minutely verruculose or asperate. 10.7–11.8μ in diameter, brownish-violet by transmitted light, black in the mass.

On bark of apple-trees, Manchester, Mass., August, 1889, *W. C. Sturgis.*

Our knowledge of this species is based upon the rather meager description and figures by Albertini and Schweinitz above referred to, and a scanty specimen preserved in the Schweinitz herbarium. There can be little doubt that the species described above is identical with that collected by Schweinitz as *Physarum sulphureum* A. and S., and it is fair to presume that Schweinitz had sufficient grounds for considering his American specimen to be identical with that found in Europe.

This species is interesting as exhibiting the close relationship existing between the two genera Physarum and Badhamia. Were it not for the few short, empty tubules which serve to connect the large nodes of the capillitium, the species would certainly be referable to Badhamia. The nature and brilliant color of the capillitium, and the absence of a columella, serve to separate it from the other yellow species of the genus Physarum.—W. C. STURGIS, *New Haven, Conn.*

EXPLANATION OF PLATE XX.—Figs. 1–4. *Comatricha caespitosa* n. sp.—Fig. 1. Habit. × 10. Fig. 2. Single sporangium with capillitium and part of wall. × 40. Fig. 3. Portion of capillitium and columella. × 240. Fig. 4. Spores. × 500.

Figs. 5–8. *Physarum sulphureum* A. and S.—Fig. 5. Habit, natural size. Fig. 6. Sporangia showing capillitium. × 50. Fig. 7. Portion of capillitium and spores. × 240. Fig. 8. Spores. × 500.

On the vegetation of hot springs.—Accidentally, in looking over some notes that I made in 1889, I found a number of references to vegetation at a very high temperature. These caused, I remember, a good deal of sensation among my friends as well as in my own mind, and I should, indeed, not venture to place them in any journal, if not

such names as Alex. von Humboldt and Sir J. D. Hooker stood behind the facts reported. Having here no means of verification of the question I choose to reproduce my notes, not only because they are very interesting, but especially in order to find out if any one is able to give an explanation of the matter. Probably my article will be seen by some botanist who has an opportunity to investigate the subject.

1. A. von Humboldt makes the following remark,[1] giving an account of his and Bonpland's expedition to the hot springs at Trinchera. "Die Ueppigkeit der Vegetation um das Becken überraschte uns. Mimosen mit zartem, gefiedertem Laub, Clusien und Feigenbäume haben ihre Wurzeln in den Boden eines Wasserstücks getrieben, dessen Temperatur 85° betrug. Ihre Aeste stehen nur zwei, drei Zoll über dem Wasserspiegel. Obgleich das Laub der Mimosen beständig vom heissen Wasserdampf befeuchtet wird, ist es doch sehr schön grün. Ein Arum mit holzigtem Stengel und pfeilförmigen Blättern wuchs sogar mitten in einer Lache von 70° Temperatur. Dieselben Pflanzenarten kommen anderswo in diesem Gebirge an Bächen vor, in denen de Thermometer nicht auf 18° steigt."—This statement indicates a very singular adaptation in the plants mentioned. The centigrade scale was used. In his immortal *Rélation historique* (II. 98) Humboldt tells the facts in the same way, and *Kosmos* (IV, 1874, 487–88) also states them.

2. Sir J. D. Hooker says[2] that a hot spring which he visited in India has a maximum temperature of 190° F. (about 90° C.), and yet he found a *Cyperus*, and an *Eleocharis*(?) there, "having their roots in water of 100°, and where they are probably exposed to a greater heat."

3. Sonnerat[3] found in a spring on Luzon *Aspalatus* and *Vitex agnus castus*, having their roots in water of 85° C.

4. Stanton found[4] on the island of Amsterdam a spring, in the bottom of which *Marchantia* and *Lycopodium* were fixed, the temperature being 186° F. (86° C.).

5. Sekondat found *Tremella* in water of 62° C., while Dunbar and Hunter in springs in Louisiana noted *Conferva* as well as higher plants growing in or being influenced by water of 50°–62° C.[5]

6. Schouw saw a moss in air of 50° C. on Ætna, Sicily.

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[1] Reisen in d. Equinoctialgegenden, ed. 1874, II. 198.

[2] Hooker's Journal of Botany I (1849). 50; Himalayan Journals II. 138.

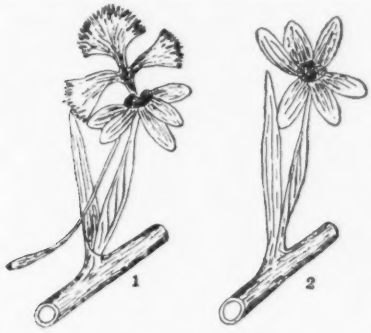
[3] Journal de Physique, 1774, p. 256; Voyage à la nouvelle Guinée, 1776, pp. 38–42.

[4] See Voit, Magazin für den neuesten Zustand der Naturkunde, I (1798), 22.

[5] See H. G. Bronn: Handbuch einer Geschichte der Natur, II (1843). 44–45 for references.

7. Goeppert found[6] the mosses, *Dicranum purpureum*, *Bryum caespiticium*, *Bryum argenteum*, *Funaria hygrometrica*, and further, *Poa annua*, *Agrostis vulgaris*, *Hypochaeris radicata*, and *Polygonum aviculare* in a place where they were in contact with steam or vapor of 63° C.; while he found, three inches under the surface, a temperature of 56° C.

On the well-known phenomenon of certain algae being found in hot springs, I could bring a good deal together here, but it is known that Cohn many years ago took this question up. For the other facts, I am able to give no explanation, when I consider the much written on temperature-maxima for growth and other life phenomena.—J. CHRISTIAN BAY, *Missouri Botanic Garden.*



HABENARIA FIMBRIATA.
1, normal form; 2, variety.

Habenaria fimbriata, var. —During a collecting tour with Mr. H. E. Sargent, in the summer of 1892, a large quantity of the type form of this orchid was found August 2nd, in full bloom, in moist woods a few miles east of Lynn, N. H. This species is much less common than the nearly related species, *H. psychodes*. The latter at the above date had barely begun to bloom, while *H. fimbriata* had in some cases passed its prime already. In color, an unusual number of spikes were nearly white and a large number were gathered in a hasty run through the woods. In addition two spikes of a very peculiar variety were found, but were not noticed at the time, or others would have been looked for. One of the two had the light purple flowers of the type while the other was white. In size and foliage there was nothing unusual about them, except that the spikes were much more slender than the type and linear rather than oblong. The flowers, however, were strangely modified, as is shown in the figures accompanying this paragraph. Fig. 1 is the ordinary form, fig. 2, the variety. In the variety the sepals and petals are all entire and alike in form and size, except as in two or three flowers on one of the spikes there is a slight suggestion of a fringed lip. The long and prominent spur, in the type moreover, is here entirely wanting, the ovary is considerably longer and more

[6] Wiegmann's Archiv für Naturgeschichte, 1 (1837). 208–210.

slender, and the bracts are most of them linear lanceolate instead of lanceolate. It would be of interest to the writer to learn whether the above variety has often been met with, and whether similar variations occur in other species or genera of this order.

Since the above was written the February number of the *Torrey Bulletin* has come to hand. Reference is there made (p. 37,) to *Habenaria blephariglottis*, var. *holopetala* Torr., as having entire petals at times, and (p. 38), to a variety of *H. ciliaris*, collected during the past season in the vicinity of New York, in which the lip was either imperfectly fringed or entire, while the spur was either very short or obsolete. The figures given above, therefore, only illustrate the extremes of variation found within the limits of the genus.—HENRY G. JESUP, *Hanover, N. H.*

EDITORIAL.

THE need of a comprehensive index to the writings of American botanists becomes more urgent every year. What Farlow's index did for writings upon fungi, should be done for every other department of the science, and provision ought also to be made for keeping the index up to date. The index to current literature in the *Bulletin of the Torrey Club*, is valuable, and a specially interesting feature of the journal, but is necessarily restricted and imperfect. It was a most excellent idea to provide an index and abstracts of the publications sent out by the experiment stations in the form of a serial, the *Experiment Station Record*, but the multiplicity of subjects included makes it rather unhandy for the use of the specialist.

There are other bibliographical aids to historical research that are of some service, but all told, the facilities for ascertaining what has been written in America upon a particular subject are meager and annoyingly imperfect.

The need of such an index was formerly not strongly felt except by a few workers, but recently it has become the fashion (may it never depart) to include in every considerable research a more or less complete historical review, and in all matters of moment to give the connection of the observations with previously recorded facts. With the present lack of any suitable index this is often a formidable task, and is usually attended with great uncertainty, particularly in regard to American records.

Could such an admirable work as Just's *Jahresbericht* be provided for the current writings of American botanists, it would not only be

serviceable upon this side of the ocean, but would be especially welcome to investigators in other countries. Commercial publishers are willing to undertake the financial management of such serials abroad, but here probably the only way to succeed would be to have the responsibility assumed by a university having a reputation and endowment that would guarantee permanency. It is very doubtful if the income from subscriptions would meet the expense of publication.

If such a serial were established, there would still remain the necessity for an index of earlier publications. Among the various ways in which this might be accomplished, probably one of the most effective would be by co-operation through the section of botany in the American Association. It could by this means be managed so as not to be a formidable undertaking. The expense of the printing might possibly be arranged for with the Association, or the Smithsonian Institution.

The sooner the work is done the shorter the task, and the more rapid and satisfactory will be the growth of botanical science upon American soil. That it must eventually be done does not admit of doubt.

CURRENT LITERATURE.

Classification of monocotyledons.

A recent monograph by Dr. A. Engler[1] will be found especially helpful to those interested in the classification of angiosperms. It will be seen that the author's arrangement of the monocotyledons differs considerably from that of Eichler, which, with slight modification, is repeated by Goebel, and also from that of Drude. Engler divides the monocotyledons into two great divisions: (1) Those with prevailing inconstancy in the number of parts of the flower, and (2) those with complete or reduced pentacyclic flowers.

The first division includes those families in which the typical nakedness of the flower, spiral arrangement, and inconstancy in the number of parts of the flower may be observed. The arrangement is easily understood, and seems to be sustained by the facts. The different series and their families are as follows:

A. Families with a prevailing inconstancy in the number of floral parts.

I. *Pandanales.*—(Pandanaceæ, Typhaceæ, Sparganiaceæ.)

[1] ENGLER, A.—Die systematische Anordnung der Monokotyledoneen Angiospermen. Akademie der wissenschaften. pp. 1–55. Berlin, 1892.

II. *Helobiæ.*—The common characteristic of this series (Triuridaceæ excepted) is that the small endosperm is destroyed by the embryo before germination. (Juncaginiaceæ, Butomaceæ, Hydrocharidaceæ, Potomogetonaceæ, Naiadaceæ, Aponogetonaceæ, Triuridaceæ.)

III. *Glumiflorеæ.*—(Cyperaceæ, Gramineæ.)

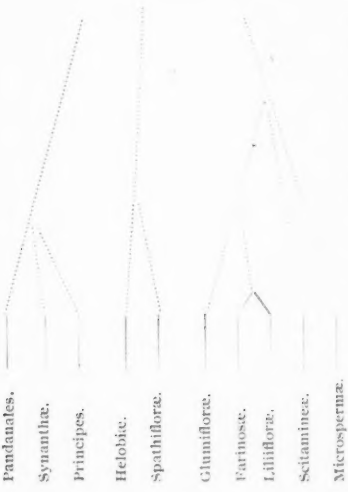
IV. *Principes.*—(Palmæ.)

V. *Synanthæ.*—(Cyclanthaceæ.)

VI. *Spathifloræ.*—(Araceæ, Lemnaceæ.)

B. Families with complete or reduced pentacyclic flowers.

VII. *Farinosæ.*—The important characteristic of this group (aside from exceptions which are explained) is the distinct mealy endosperm whose cells have thin walls and are filled with connected starch grains. (Flagellariaceæ, Restionaceæ, Centrolepidaceæ, Mayaceæ, Xyridaceæ, Eriocaulaceæ, Rapataceæ, Bromeliaceæ, Commelinaceæ, Pontederiaceæ, Philydraceæ.)



VIII. *Liliiflorеæ.* — Endosperm mostly of thick-walled cells, containing only protoplasm and oil. (Juncaceæ, Stemonaceæ, Liliaceæ. Hemodoraceæ, Velloziaceæ, Taccaceæ, Dioscoreaceæ, Iridaceæ.)

IX. *Scitamineæ.*—(Musæ, Zingiberaceæ, Cannеæ, Marantеæ.)

X. *Microspermæ.*—(Orchidaceæ, Apostasieæ, Burmanniaceæ.)

The accompanying diagram will serve to give a general view of the series of monocotyledons according to their mutual relationships.

D. M. Mottier.

Minor Notices.

The North American species of Lespedeza form the subject of the 34th contribution from the Herbarium of Columbia College, which appears in *Trans. N. Y. Acad.* XII, under the authorship of N. L. Britton. Twelve species are recognized, full descriptions and synonymy given, and two new varieties proposed. The delimitation of these species has always been a troublesome thing, and as Dr. Britton has had the opportunity of examining most of the type specimens it is to be hoped that the "straightening out" has been effectual.

THE SECOND and enlarged edition has reached us of a compact and handy little flora of the East Frisian islands,[1] which lie like a barrier off the coast of Holland and East Friesland. After a brief account of the flora, suitable keys to the families of angiosperms are followed by concise description of the species. We should be glad to see some such floras of parts of this country.

NOTES AND NEWS.

AN INTERESTING account of the Ray herbarium is given by Mr. James Britton in the *Journal of Botany* for April.

REV. ARTHUR C. WAGHORNE, of Newfoundland, is offering sets of Newfoundland and Labrador plants for sale. The plants are authoritatively named and include cryptogamic material. His address is at New Harbor.

BULLETINS 31–40, of the Botanical Department of Jamaica, in addition to much useful information concerning matters that directly pertain to the Public Gardens and Plantations, contain a continuation of the synoptical list of the Ferns of Jamaica, by Superintendent Jenman, including descriptions of new species.

DR. KARL PRANTL'S work in the preparation of the great "Natürlichen Pflanzenfamilien" will be continued by Dr. Engler alone. Parts 80 and 81 of this work, just issued, contain Rhizophoraceæ by Schimper, Myrtaceæ by Niedenzu, Sterculiaceæ by Schumann, Dilleniaceæ and Ochnaceæ by Gilg, and Eucryphiaceæ by Focke.

THE GAZETTE would be glad to give the names and addresses of all botanists who are to be at the World's Fair in charge of exhibits, so that visiting botanists may readily find them. The form of announcement will be as follows:

DR. CHARLES F. MILLSPAUGH: in charge of West Virginia Forestry Exhibit: intersection main aisles, Forestry Building.

THE SECOND publication of the Botanical Survey of Nebraska, which is being conducted by the Botanical Seminar of the State University, makes a report on collections made in 1892. It includes notes and lists of plants from the Sand Hill region of Sheridan and Cherry counties, notes on the cañon flora of Sioux county, and miscellaneous additions to the state flora, together with new or noteworthy species.

A BIOGRAPHICAL sketch of the late Dr. J. S. Newberry, prepared by Dr. N. L. Britton, appears in the *Bulletin of the Torrey Botanical Club* for March, including a fine portrait and full bibliography of his botanical writings. A plate of Torrey's genus Newberrya is also given. The sketch is written by one of Dr. Newberry's associates, who had abund-

[1] BUCHENAU, FRANZ:—Flora der Ostfriesischen Inseln. 12mo. pp. viii, 176. Norden u. Norderney; H. Braams. 1891.

ant opportunity to know his worth. Although more strictly a geologist, Dr. Newberry's contributions to botany are surprisingly numerous, especially in the field of paleobotany. His connection with some of the early and important exploring expeditions enabled him to do much service to botany in the way of plant collections, no less than ten living species being named in his honor, in addition to the genus referred to. Of the 197 titles included in his bibliography, 39 are credited to botany.

Dr. Otto Kuntze, having returned from his South American trip, asks that the international committee on botanical nomenclature give him opportunity to demonstrate what he calls "the absurdities of the Genoa Congress." There can be no doubt but that any botanist who has anything to say concerning nomenclature will be gladly heard. The committee is simply a representative body, and is merely intended to formulate the opinion of the majority of working botanists.

The well-known naturalist and explorer of Brazil, Central America and Mexico, August B. Ghiesbreght, died on the 7th of February, in the eighty-second year of his age. In numerous and prolonged travels throughout all parts of tropical America Ghiesbreght has brought to light great numbers of new and interesting plants, and his collections enrich all of the principal herbaria and gardens of the world. A glance at the monumental "Biologia Centrali-Americana" is sufficient to show the vast extent of his labors, which are commemorated by the specific names of many plants and animals and especially in the arboreous fig-wort, *Ghiesbreghtia grandiflora*, which Dr. Gray dedicated to him.

Mr. Henry E. Seaton, Assistant Curator of the Gray Herbarium at Harvard University, died suddenly April 30th. He was a young botanist of unusual promise. In the summer of 1891 he made a botanical exploration of Mt. Orizaba, and had just completed a study of his material for distribution. In connection with Dr. Coulter he had determined the Compositae of Mr. John Donnell Smith's Guatemalan collection, and during this past winter, in connection with Dr. Robinson, determined the last Pringle collection, which has just been distributed. Trained thoroughly in modern methods he was bringing to the study of systematic botany the knowledge of general morphology which it so much demands, and systematists can ill afford to lose such carefully prepared young men.

The death of Alphonse De Candolle, April 4th, at his home in Geneva, in his eighty-seventh year, removes not only one of the oldest but one of the greatest of the botanists of our time. His long life of incessant activity, continuing the labors and reputation of his father, Auguste Pyramus De Candolle, has left the science of botany greatly his debtor. His name must always be familiar to students of systematic botany, both on account of the numerous monographs that he either prepared or directed, and because of the important *Lois de la Nomenclature Botanique* which he formulated in 1867 for the Paris Congress, and which is now referred to as the "Paris Code." The extent of his labors is marvelous, and when one comes to put together his bibliography it seems impossible that one man could have accomplished so much. That monumental work, the *Prodromus*, was be-

gun by his father in 1824, under whose direction seven volumes were published. The remaining ten volumes bear the name of Alphonse De Candolle, and when the dicotyledons had been completed, and the work as originally planned discontinued, under the same untiring direction seven volumes entitled *Monographiæ Phanerogamarum* appeared as a continuation in fact if not in form. Of the usefulness of this greatest production of the De Candolles it is not necessary for any systematist to speak. It is not merely useful, it is indispensible. De Candolle's name will also always be associated with geographical botany, for his *Geographic Botanique* (1855) is one of the classics of that subject. In 1880 he published his *La Phytographie*, an exceedingly useful book, packed full of life-long experience and information. It would be useless to attempt to even mention all his work. He was more than a self-centered writer, for even in his advancing years his enormous correspondence kept him in constant and kindly touch with the younger generation of botanists, and his frank and helpful letters were written without stint. The name of De Candolle is worthily perpetuated in the son Casimir, and the family record of three generations of distinguished botanists is a wonderful one.

Dr. Daniel C. Eaton, of Yale University, and Mr. Edwin Faxon, of Jamaica Plain, propose to issue in about two years sets of specimens of North American Sphagna. The number of species attributed to the United States and British America is now nearly fifty, and many of them have never been distributed. For anything like a full series, there should be about one hundred and thirty forms in the collection. Not less than sixty sets of the specimens will be prepared and a set will be given to each person who may supply three or more acceptable forms in quantity sufficient for distribution. The remaining sets will be used for foreign exchanges, and for sale. Promises of assistance have been received already from collectors, and others, and there is every reason to hope that the collection may be made to include nearly all the known species of temperate North America. Any species that are in the least degree doubtful will be submitted to Dr. C. Warnstorf, for final determination. The coöperation of American botanists is respectfully asked for. Letters or collections may be addressed to either of the above named.

Isaac Burk, our best authority on Philadelphia ballast plants, and long prominently connected with the botanical work of the Philadelphia Academy of Sciences, died March 29th, in his 77th year. On account of poor health and the need of out-door employment he had charge for over thirty years of a *Philadelphia Ledger* route. He was a student of botany from boyhood, and all his leisure time was occupied in making collections and in study of natural science. He arranged a large part of the collection belonging to the Philadelphia Academy, of which he was a life member. In 1880 he presented his private collection to the Biological Department of the University of Pennsylvania. It is there maintained as a separate collection, and is specially rich in local and ballast plants. He was the author of a series of articles on the flora of Fairmount Park, published in the *Ledger* just before the Centennial. Several of his papers also appeared in the *Proceedings of the Phil. Acad.* Dr. Wm. H. Burk, botanist of the Peary expedition is his son.

In 1890, Prof. Fr. Elfving, of Helsingfors, gave a communication on physiological action at a distance, showing a remarkable kind of movements that took place in the sporangium-bearers of Phycomyces, when exposed to the influence of certain bodies placed in their neighborhood, such as metals of different kinds, etc. Iron attracts the growing sporangium-bearers very distinctly; less noticeable was the effect of zinc and aluminium; gold, silver, nickel, lead, and copper, etc., had no effect, but roots of several common plants, *Vicia*, *Phaseolus*, *Pisum*, and others, as well as sealing wax, rosin, and smooth paper, had a very marked effect, attracting the sporangium-bearers more or less. The filaments mutually repulsed one another. Elfving thought that electricity probably was active here. Prof. Errera, of Brussels, has now[2] given a new explanation of these remarkable movements, namely, that they are due to hydrotropism, and his facts are the following: China clay, which is very hygroscopic, attracts energetically, but china exhibits no attraction; agate, which is very hygroscopic,[3] strongly attracts the filaments, while rock-crystal does not exhibit any effect, owing to its non-hygroscopic properties. The sporangium-bearers, being thus a fine reagent on hygroscopic power, were used by Errera to test that property on camphor; this substance is, in fact, hygroscopic.—Bay.

The following extract from the annual report of the President of Harvard University is of interest to botanists: "On the death of Dr. Watson, Curator of the Herbarium from 1874 to 1892, Benjamin Lincoln Robinson, Ph. D., was appointed Curator, and in August last Mr. Henry E. Seaton, who had been instructor in botany and Curator of the Herbarium at the University of Indiana, was appointed Assistant Curator for the current academic year. It was also possible to appoint more assistants than ever before. The liberal gifts to the Herbarium for immediate use, and the good income from Professor Asa Gray's copyrights ($2,817.33 in 1892) permit this increase of expenditure at the Herbarium. The result has been a great increase of the work accomplished, over 20,000 plants having been added to the collection during the year. Moreover, it has become possible for the Curator to resume work on the Synoptical Flora of North America, the great work first interrupted by the death of Dr. Gray, and then by the death of Dr. Watson. In the present debates about botanical nomenclature, it will be the policy of the Herbarium to act a conservative part; no serious departure will be made from the nomenclature thus far used in the Herbarium and in the published works of its Director and Curators."

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[1] Ueber physiologische Fernwirkung einger Koerper. Helsingfors, 1890, 2 plates.

[2] On the cause of physiological action at a distance. Annals of Botany, VI, 373 (1892).

[3] Jhmori: Weidemann's Annalen, 1887.

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